INTRODUCTION TO THE PAPERS OF WG15

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TECHNOLOGIES AND RESOURCES IN MATHEMATICS EDUCATION

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INTRODUCTION

Technologies in mathematics education have been a topic of the working group since the CERME 1999. Since then, technologies as well as research in this field have significantly evolved. In particular, recent years have brought about an important shift in considering technologies within a wide range of resources for students, teachers and teacher educators. There have been new developments concerning software, hand-held technology, online classroom activities, but also more traditional geometry tools, curricular materials, textbooks etc. The introduction of the term "resource" in the title of the technology working group since the CERME 6 congress in 2009 reflects this shift (Gueudet, Bottino, Chiappini, Hegedus & Weigand, 2010).

Technologies and resources have become more abundant and accessible, bringing about some changes in math teaching and learning (Hoyles & Lagrange 2010). They offer new possibilities for representation, modelling, simulation and access to information and knowledge (Tooke & Henderson 2001), and suggest new ways of generating student engagement, motivation and creativity (Passey, Rogers, Machell & McHugh, 2004). Teaching methods with technologies are increasingly focusing on problem-solving approaches (Fuglestad, 2009). Technologies also offer means of collaborating and sharing resources between students and teachers (Trouche, Hivon, Noss, & Wilensky, 2010). But presently, despite the use of digital technologies in the public and business world, and the tremendous number of research and practical classroom papers, the use of technologies in mathematics education and the impact on the change of curricula are still limited (Hoyles & Lagrange, 2010).

The group organized the contributions around four main themes: (1) Design and use of technologies and resources, (2) Technologies, resources and teachers' professional development, (3) Students' learning with technologies and resources, and (4) Technology-based assessment in math teaching. Surprisingly, the latter does not appear as a matter of concern since all papers addressed the first three themes.

The group work was organized in two sub-groups discussing respectively the issues of technologies and resources in relation with teachers' professional development (theme 2), and the issues related to the design of technologies and resources and their impact on students' learning (themes 1 and 3). In the following, we give a brief overview of the group work according to the three above-mentioned themes.

THEMES IN WG15

1) Design and use of technologies and resources

Papers related to this theme concern on the one hand the design of innovative technological tools or resources. Ladel & Kortenkamp design and develop a multi-touch technology for learning numbers and operations, Sabra & Trouche study the design by a community of teachers of online secondary school math textbook. On the other hand, the use of existing technological tools and resources are addressed, such as the use by teachers of specific curricular material accompanying TI-Nspire (Persson) or of math textbooks (Özgeldi & Çakiroğlu), students' use of TI-Nspire technology (Aldon), of a spreadsheet (Tabach) or of graphic calculators (Consciência & Oliveira; Storfossen). The question of the design of specific tools for students with special needs, such as visually impaired students (Kohanová) or students with dyscalculia, was raised. In the group discussions, *added value* of technology appeared as the most important element determining what kind of tool to use, how and what for. Various roles have been assigned to technology in math education by the participants: fostering motivation, enhancing calculation, visualization, (guided) exploration, hands-on experience on abstract models, allowing validation by providing feedback, but also helping teachers teach with systems providing individualized learning paths based on students' competence diagnosis.

2) Technologies, resources and teachers' professional development

Papers related to this theme investigate teachers' use of technologies and resources (both inside and outside the classroom), factors affecting their integration in classrooms, and issues related to teachers' professional development. These issues are addressed focusing on different aspects, from different perspectives and adopting different methodologies. The analysis of the teachers' practice in classroom is investigated at different levels of granularity, each one requiring the design and use of different methodological tools, from fine-grained analyses (Billington), through survey studies (Bretscher), to studies combining both qualitative and quantitative methods (Drijvers). As it clearly emerged, the integration of technologies and resources in the classroom poses a number of challenges to teachers, several of which can be described and discussed in terms of the Technological Pedagogical Content Knowledge that they need to develop (Fuglestad). From the instrumental perspective, some of these challenges can be related to the need for the teacher to transform an ICT tool both to a mathematical and a didactical instrument (Haspekian). All these considerations raise the issue of the teachers' professional development and how it impacts the teachers' use of technology. Studies concerning this issue regarded, for instance, the actual (Amado) or intended use (Pittalis) of technology by pre-service or in-service teachers, who attended specific training courses on technologies in math education. The issue of teachers' professional development is strictly related to the issue of the dissemination of research results

among teachers. Developing communities involving both researchers and teachers is proposed as a means to trigger collaboration and communication among them and to foster the dissemination of research results (Lagrange).

3) Students' learning with technologies and resources

Papers addressing issues related to this theme concerned both widespread technological tools, such as dynamic geometry software (Attorps *et al*.; Camacho & Santos), symbolic or graphic calculator (Consciência & Oliveira; Storfossen; Weigand), and more innovative tools like TI-Nspire handheld device (Aldon; Persson) or online games (Kolovou & van den Heuvel-Panhuizen). Some of these papers focus on *student-tool interactions* in order to study processes of students' appropriation of the tool (Consciência & Oliveira; Camacho & Santos) or students' transition between various tools (Tsitsos & Stathopoulou). These studies draw mostly on the *instrumental approach* (Rabardel 2002) as a theoretical framework specifically designed for studying teaching and learning phenomena involving technology. In other papers technologies are considered rather as a *tool mediating mathematics learning*. The choice of a tool and the design of appropriate tasks are the main concerns in these papers (Attorps *et al.*; Kolovou & van den Heuvel-Panhuizen). The task design is supported by two main theoretical approaches: *variation theory* (Marton & Booth, 1997) and *theory of didactical situations* (Brousseau, 1997). Studies involving innovative pieces of software investigate their potentialities for mathematics learning (Ladel & Kortenkamp) as well as for organizing and exploiting the internal resources (Aldon). Another important issue discussed in the group was the question of *assessment* of students' competencies (Weigand): what kind of knowledge and skills developed by the student working with technologies do we want to assess and how can we assess it?

CONCLUSION

What lessons can be learnt from the work of the WG15? Although the three themes proposed to the working group appeared as strongly articulated, some important issues emerged for each of them. The design of technologies and resources seems to be driven by the consideration of their *added-value* for the teaching and learning mathematics and relies on the *users' feedback*, which becomes part of the design process. The group discussions allowed getting a deeper insight into the *complexity of ICT integration* in teachers' practices, which requires a *double instrumental genesis* in teachers: a personal one, yielding an instrument for teachers' math activity, and a professional one, yielding an instrument for math teaching. This raises the issue of teacher training focusing on the development of teachers' technological pedagogical content knowledge. The idea of teachers' communities sharing resources and practices in using ICT emerges as a powerful means to favour teachers' professional development. In studying students' learning with technologies, the *instrumental approach* becomes widely used to analyse student-tool interaction. It

highlights a strong interconnectedness of mathematical and technological knowledge. However, the impact of technology on students' achievements appeared as very difficult to measure, mostly due to the lack of appropriate methodology.

What perspectives can be outlined for the future CERME conference? There is still a need to develop a comprehensive theoretical framework to support teachers in their integration of ICT to the benefit of students' learning and methodological tools to evaluate the impact of using ICT on students' learning and teachers' practices. Emerging topics, such as communities of practice, quality of resources or best practices, require further theoretical and methodological development. Finally, some topics, which are under-represented, would deserve researchers' interest: use of "new" new technologies, such as interactive white board, mobile devices, Web 2.0, as well as designing ICT for students with special needs.

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